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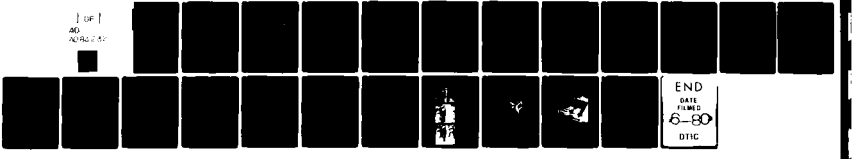

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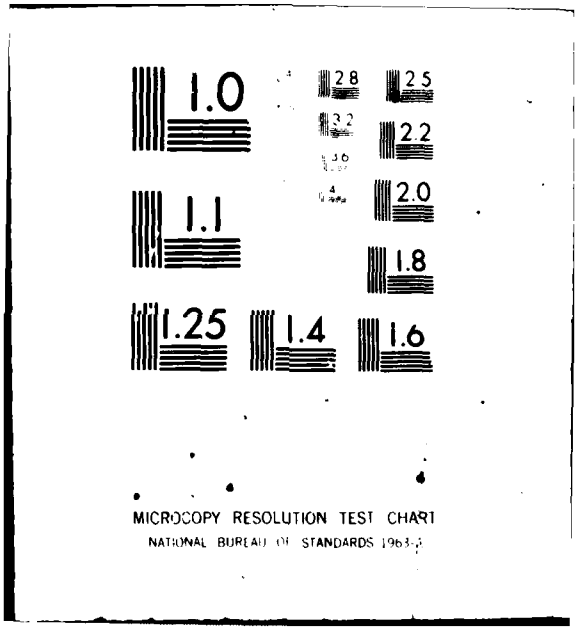
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Structures Technical Memorandum 306

WEATHERING TESTS ON PROTECTIVE HELMETS APPROVED TO AUSTRALIAN STANDARD AS 1698 (FOR VEHICLE USERS). INTERIM REPORT NO. 1

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S.R. SARRAILHE and G.A. THOMAS

SUMMARY

This interim report describes the methodology to be used to investigate the effect of weathering on the performance of protective (crash) helmets approved to Australian Standard AS 1698. The results of the pre-exposure inspections and tests are also provided.

The investigation is planned to continue for three years with inspections and tests after six months, one year, eighteen months, two and three years after the commencement of the exposure.

The work is sponsored by the Office of Road Safety, Department of Transport.

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16. ABSTRACT:

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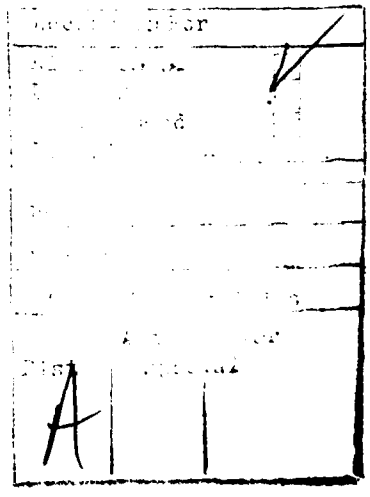

1. INTRODUCTION

The Australian Standard concerning Helmets for Vehicle Users, AS 1698 (Standards Association of Australia 1974) was issued in 1974 and was based on an internationally accepted American Standard ANSI Z90-1, (American National Standards Institute 1971). These, and other standards examined, contained a warning about durability, for example AS 1698 stated that the "Materials shall be of a durable quality such that their characteristics will not undergo appreciable alteration under the influence of ageing or the circumstances of use to which the helmet is normally subjected, i.e. sunlight .....".

Despite such warnings there was evidence in reports in Choice magazine (1975) and by Sarrailhe (1978) that the resistance to penetration of some helmets was reduced by exposure to the weather, and the normally tough but ductile shells became brittle. Aware of this situation, the Australian Standard was amended in September 1977 (Standards Association of Australia 1977) to provide a more forceful warning which required that materials "should be known not to undergo appreciable alteration .....".

Some of the evidence of deterioration (Choice magazine 1975) was presented to the House of Representatives Standing Committee on Road Safety and the report of their investigation into motor-cycle and bicycle safety (1978) contained criticism of the lack of a quantitative test. However there are difficulties with specifying such a test and no suitable test has yet been developed in Australia or overseas. The technical committee concerned with the standard considered that improvements in the materials used in the construction of current helmets should make them more durable.

This investigation is being undertaken to check this belief by periodically testing a group of approved helmets which are exposed to the weather. The investigation is intended to show if any of the common materials deteriorate seriously in an unreasonably short time and to indicate how long a typical helmet could be expected to last and provide the protection specified in the standard.

These objectives are in accord with a conclusion of the House of Representatives Committee that the "compliance to AS 1698 of helmets in the market place (should) be monitored by a Government sponsored independent testing agency" (Hansard 1978).

If the investigation shows the helmets to be satisfactory, only occasional monitoring will be required. However if the investigation shows that artificial ageing tests are necessary an attempt will be made to develop an appropriate test procedure for inclusion in the standard, and the sets of paired helmets which have been stored and naturally exposed will facilitate comparison of artificial and natural ageing.

The helmets selected for testing were chosen as typical examples of the types and materials commonly used and high, middle and lower priced models were included. In selecting the helmets there was no intention to imply either endorsement or doubt about the performance of any brand.

The program is sponsored by the Office of Road Safety, Department of Transport.

2. METHODOLOGY

Three samples of several different helmet types will be exposed on the roof of the laboratory at Fishermen's Bend, and three similar samples will be kept in darkened storage. Two of the exposed helmets (the exposed test helmets) and two of the stored helmets (the stored test helmets) will be tested periodically to determine resistance to penetration. After each stage of testing, exposed helmets will be returned to the roof for further exposure, unless there has been a large reduction in performance. If appreciable deterioration (defined later) is detected, the helmet which was exposed without testing (exposed reference) and the helmet which was stored without testing (stored reference) will be impacted as well as the helmets routinely tested.

The exposure is expected to take place over three years with testing before exposure, after 6 months, 12 months, 18 months, 2 and 3 years.

As repeated testing will involve multiple impacts and tests over a wide area of the shell, a seventh helmet was tested at all the proposed impact points to check for variations in performance not associated with ageing. This "impact survey" took place before the exposure commenced.

3. DETERMINATION OF RESISTANCE TO PENETRATION

The helmet is supported on a headform and impacted by a 3 Kg indentor allowed to fall on the helmet from a height of 3 metres. The procedure and indentor comply with the requirements of the Australian Standard and overseas standards:

American National Standards Institute Z90.1-1971 (1971)

Motor Vehicle Safety Standard 218 (1973)

Snell Memorial Foundation '70 (1970)

Snell Memorial Foundation '75 (1975).

The only variations from these standards are:

1. A wooden headform made at the Aeronautical Research Laboratories (ARL) to the shape defined in the 'ISO specifications' (International Standard Organization 1970 - Size J) is used in preference to the metal headform usually used, because the mounting of the ARL headform is adjustable for multiple impacts. Previous comparative tests with the metal and wooden headform showed that there was no difference in results. (Sarrilahe 1978).

2. Multiple impacts will be used and not the two widely spaced impacts detailed in the standards.

3. Additional tests with a two metre drop height will be carried out if the 3 metre impact results in penetration to the headform.

The headform and mounting are shown on Figs. 1a, b, and c. The axis of the headform can be set 60, 40 and 20 degrees from vertical and the headform can be rotated to apply the impact towards the front or rear (30 degrees either side of the transverse plane) on either side of the helmet. Locations are identified as -60, -40, -20 (right side), or +60, +40, +20 (left side) and F or B (front or back). The headform is positioned so that the impact is approximately perpendicular to the shell, but because of asphericallity this produces some variation in the precise locations of the impacts. Typical locations on the impact survey sample (A) of the Stadium helmet and the levels of Test Line of AS 1698 are indicated in Fig. 2.

Prevention of penetration to the headform is the criterion for compliance with the standard. Penetration to the headform can be identified by electrical methods or marks on the headform, but a laminate of white paper and carbon paper, on the headform, in the impact region has been found to be sensitive, discriminating and unambiguous (Sarrailhe 1978), and this method will be used.

At each stage (after each period of exposure), the test helmets will be impacted at both the F and B locations at one angular position.

4. CRITERIA FOR DETERIORATION

In the following criteria it is assumed that the helmets will prevent penetration to the headform when they are new. This should be the case because all claim to comply with AS 1698, but as a check, four helmets of each type were tested before exposure commenced. The two "reference helmets" were not tested before exposure.

Deterioration will be indicated if any impact from 3 metres results in penetration to the headform. If this occurs the scheduled number of 3 metre tests will be completed and the 4 "test helmets" will also be subjected to impacts from 2 metres.

Deterioration will be deemed appreciable if penetration to the headform occurs in (a) the majority of impacts onto the exposed helmets from 3 metres, or (b) in any of the impacts from 2 metres. If either condition occurs, the "reference helmets" will be tested with 3 metre and if necessary 2 metre impacts. The exposure and periodic testing will be terminated when the majority of 2 metre impacts cause penetration.

Any dramatic change in the mode of failure or evidence of brittle behaviour may be considered as a cause for testing the reference helmets. Any helmet type which allows penetration to the headform when tested before exposure will require special consideration with regard to the definitions.

5. EXPOSURE PROGRAMME

The "exposed helmets" will be exposed to the weather on the roof of the Wing Bay ARL building no. 3, on the rack shown in Fig. 3. They will be positioned on a north facing roof and inclined to direct the top of the helmet, and therefore the centre of the test area, towards the average azimuth of the sun. Radiation at the top of the helmet will be more intense than that at the sides, but the grouping of the impacts ensures that all locations receive some direct sunlight. Melbourne weather records will be obtained from the Bureau of Meteorology.

ARL is situated in an industrial area near the sea with a foundry adjacent and chemical plants not far away; nevertheless, it is an area where people live, work and ride motor-cycles.

To prevent the ingress of water or water vapour into the fibre reinforced shells, the holes made by the periodic impact tests will be filled with "Fil-o-bond" plastic putty and sealed with white two-part polyurethane paint.

6. RESULTS OF THE PRE-EXPOSURE TESTS

6.1 Initial Checks

The 7* helmets of each type were examined and paired to match the colours and sizes of the exposed and stored samples. Reference letters were allocated with the following convention:

A Impact survey helmet

B Exposed reference helmet

C Stored reference helmet

D), E) Exposed test helmet

F), G) Stored test helmet

Each helmet was weighed, measured, and other particulars recorded as shown in Tables 1a to 1f and summarized in Table 2 (the "size" column data was taken from the helmet label; the length, width, mass and circumference were measured). The helmets were subject to the pre-exposure impact tests, prepared for exposure and mounted on the roof.

6.2 Results of the Pre-Exposure Impact Tests

The pre-exposure tests were carried out on the test helmets D, E, F and G at test locations -60F and -60B, and on the impact survey helmets A at -60, -40 and -20, F and B. The Arai R6M, Arai S75, Bell Magnum, Centurian and El Dorado, prevented penetration of the indenter to the headform in every impact. The Stadium 9 failed to prevent penetration to the headform in tests at -60F and -40F on the impact survey helmet and at -60F on three of the other helmets (E, F and G). These three helmets were impacted at +60F with two metre drops and penetration was prevented. The Impact survey helmet resisted three metre impacts at -60B, -40B, -20F and -20B and this suggests that there is a weaker region over the temple. Results for this helmet are given in Table 3.

The other helmets resisted penetration in all locations tested, so the survey did not reveal any weak regions.

* Only six Bell Magnum helmets were available and the impact survey was omitted.

In no case did the result of an impact appear to be influenced by a previous test, i.e. initial results were not 'better' than later tests. This justifies the method of using the same helmets for periodic testing.

None of the helmets showed brittle behaviour. The holes made in the glass fibre reinforced shells were small with very little delamination and the depressions in the polycarbonate shells showed the ductile properties of the material.

7. CONCLUSIONS

1) The results of the impact survey justifies the use of the same helmets for repeated testing after the successive exposure periods.

2) Only one helmet showed a weak region in the test area.

3) The Stadium Project 9 failed to prevent the indentor penetrating to the headform over the temple, in five tests on four helmets. It is considered that this constituates a failure to comply with the requirements of AS 1698.

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TABLE 1a

HELMET WEATHERING TRIALS

HELMET DETAILS

Make: ARAI Model: R-6M Shell: Fibreglass Reinforced Polyester Resin

Liner: Expanded Polystyrene

HELMET	Colour	Production Date	SAA Serial No.	Size cm	Length mm	Width mm	Mass gm	Circumference mm
A	White	July '78	B535336	L 57-59	275	230	1221	808
B	Yellow	Dec. '78	B541528	S 53-55	270	230	1196	790
C	Yellow	Dec. '78	B541700	M 55-57	275	230	1218	808
D	Yellow	March '78	B509090	L 57-59	275	230	1195	808
E	Red	Dec. '78	B541204	M 55-57	275	231	1209	808
F	Red	July '78	B535706	L 57-59	275	232	1184	808
G	Yellow	Dec. '78	B541556	S 53-55	270	230	1190	790

REMARKS:

Size L - Large

M - Medium

S - Small

TABLE 1b

HELMET WEATHERING TRIALS

HELMET DETAILS

Make: ARAI Model: S-75 Shell: Fibreglass Reinforced Polyester Resin

Liner: Expanded Polystyrene

HELMET	Colour	Production Date	SAA Serial No.	Size cm	Length mm	Width mm	Mass gm	Circumference mm
A	White	Aug. '77	Y172400	S 53-55	275	232	1244	805
B	Orange	Oct. '77	Y130105	L 57-59	283	238	1320	825
C	Orange	Aug. '77	Y172686	M 55-57	283	238	1291	825
D	White	Aug. '77	Y172541	L 57-59	283	238	1279	822
E	Yellow	Dec. '78	B540719	M 55-57	283	238	1300	822
F	White	Not Known	B534715	M 55-57	283	238	1295	826
G	Yellow	Dec. '78	B540693	S 53-55	275	232	1282	806

REMARKS:

Size L - Large

M - Medium

S - Small

TABLE 1c

HELMET WEATHERING TRIALS

HELMET DETAILS

Make: BELL Model: Super Magnum Shell: Fibreglass Reinforced Polyester Resin

Liner: Expanded Polystyrene (with thin plastic inner shell)

HELMET	Colour	Production Date	SAA Serial No.	Size cm in.	Length mm	Width mm	Mass gm	Circumference 5 cm up from edge at rear
B	White	H1.06	W24993	56 (7)	269	223	1188	775
C	White	B11.0	W31640	56 (7)	269	221	1230	776
D	Orange	J11.1	W30000	55 (6 7/8)	269	222	1239	775
E	Grey	J10.8	W29889	54 (6 3/4)	269	223	1236	774
F	White	J11.6	W30295	54 (6 3/4)	267	222	1232	770
G	Orange	J11.0	W29996	63 (7 7/8)	291	239	1362	835

TABLE 1d

HELMET WEATHERING TRIALS

HELMET DETAILS

Make: Centurion Model: 150 Shell: Polycarbonate

Liner: Expanded Polystyrene

HELMET	Colour	Production Date	SAA Serial No.	Size cm	Length mm	Width mm	Mass gm	Circumference mm
A	Blue	Feb. '77	W114323	3 58-59	275	234	1135	803
B	Blue	Feb. '77	W113520	4 60-61	275	234	1137	803
C	Blue	Feb. '77	W113507	4 60-61	275	234	1140	803
D	Blue	Feb. '77	W117926	4 60-61	275	234	1117	803
E	Blue	Feb. '77	W115802	4 60-61	275	234	1119	803
F	Blue	Feb. '77	W113508	4 60-61	275	234	1132	803
G	Blue	Feb. '77	W113500	4 60-61	275	234	1126	803

REMARKS:

Size 3 - Medium

4 - Large

TABLE 1e

HELMET WEATHERING TRIALS

HELMET DETAILS

Make: Eldorado Model: MH1 Shell: Polycarbonate

Liner: Polystyrene

HELMET	Colour	Production Date	SAA Serial No.	Size cm	Length mm	Width mm	Mass gm	Circumference mm
A	White	Nov. '77	Y204075	S 54-57	281	237	1250	820
B	Yellow	Dec. '77	Y204300	S 54-57	282	235	1265	820
C	White	Nov. '77	Y181955	S 54-57	280	235	1247	820
D	Yellow	July '77	Y183833	M 57-59	280	236	1250	820
E	White	Nov. '77	Y181861	S 54-57	280	235	1237	820
F	Yellow	May '77	Y183562	M 57-59	280	235	1240	820
G	White	Nov. '77	Y181974	S 57-59	280	235	1284	820

REMARKS:

Size S - Small

M - Medium

TABLE 1f

HELMET WEATHERING TRIALS

HELMET DETAILS

Make: Stadium Model: Project 9 Shell: Polycarbonate

Liner: Expanded Polystyrene

HELMET	Colour	Production Date	SAA Serial No.	Size	Length mm	Width mm	Mass gm	Circumference mm
A	Yellow	Nov. '76	V779735	4	265	229	1014	780
B	Yellow	Nov. '76	V778482	4	265	228	1000	780
C	Yellow	Nov. '76	V778298	4	265	228	1000	-
D	Yellow	Nov. '76	V779653	4	265	229	1015	780
E	White	Nov. '76	V778463	4	265	229	1000	-
F	Yellow	Jan' 77	V781260	3	265	229	1020	-
G	White	Nov. '76	R261194	3	265	229	1005	780

REMARKS:

Size 4 larger than 3.

TABLE 2

HELMET WEATHERING TRIALS

HELMET DETAILS

SUMMARY ON HELMET DATA

HELMET MAKE	Colour	Production Date	Shell Standard	Size	Length mm	Width mm	Mass gm	Circumference mm
ARAI RM6	White Yellow Red	July '78 Dec. '78	G.R.P. Z90.71	Small Medium Large	270 275 275	230 230 230	1190 1200 1200	790 808 808
ARAI S75	White Yellow Orange	Aug. '77 Dec. '78	G.R.P. Snell 75	Small Medium Large	275 283 283	232 238 238	1244 1291 1320	805 825 825
BELL Super Magnum	White Orange Grey	-	G.R.P. Snell 70	Small Large	269 291	222 239	1230 1362	775 835
CENTURION 150	Blue	Feb. '77 (all)	Pc -	3 4	275	234	1135 1117 to 1140	803
ELDORADO MH1	Yellow White	May '77 Dec. '77	Pc -	Small Medium	280	236	1237 to 1284 1240 to 1250	820
STADIUM 9	Yellow White	Nov. '76 Jan. '77	Pc -	3 4	265	229	1005 1020	780

REMARKS:

G.R.P. - Glass Reinforced Plastic

Pc - Polycarbonate

TABLE 3

HELMET WEATHERING TRIALS

Make: Stadium Model: Stadium 9 Colour: Various

Label: AS 1698

Reference Tests	Impact Locations	-60 F	-60 B	-40 F	-40 B	-20 F	-20 B	+60 F	+60 B	+40 F	+40 B	+20 F	+20 B
A. Impact Survey	Result 3 m drop[1]	x	o	x	o	o	o						
Colour: Yellow	Result 2 m drop							o	o				
Date: 27.4.79													
B. Exposed reference	Date:												
Colour: Yellow													
Exposure period:	Result 3 m drop												
	Result 2 m drop												
C. Stored reference	Date:												
Colour: Yellow													
Stored period	Result 3 m drop												
	Result 2 m drop												
Continuing tests	exposed from :	none						none					
	to :												
Exposure or Storage	Test period from	27.4.79						27.4.79					
	to	2.5.79						2.5.79					
D. Exposed	Result 3 m drop	o	o										
Colour Yellow	Result 2 m drop												
E. Exposed	Result 3 m drop	x	o										
Colour: White	Result 2 m drop							o					
F. Control	Result 3 m drop	x	o										
Colour	Result 2 m drop							o					
G. Control	Result 3 m drop	x	o										
Colour: White	Result 2 m drop							o					

Note: 1. x Penetrated to headform
o Did not penetrate to headform

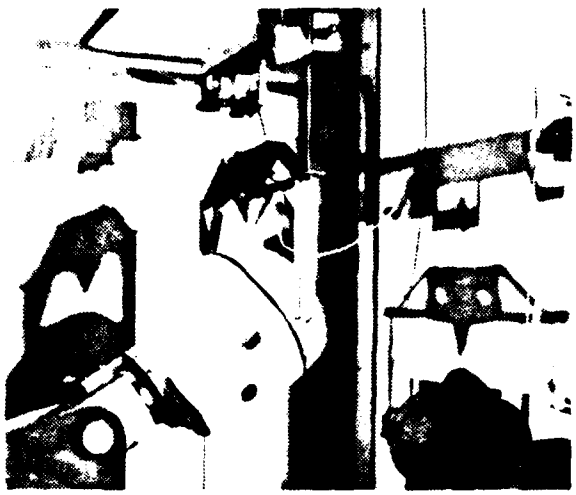

Fig. 1a
Impact location
-30 F
axis of [illegible] to vertical
impact 30° to [illegible]

Fig. 1b
Impact location
-30 F
axis of [illegible] to vertical
impact 30° to [illegible]

Fig. 1c
Impact location
-30 F
axis of [illegible] to vertical
impact 30° to [illegible]

HEAD FORM AND IMPACTOR

FIG. 2 TYPICAL IMPACT LOCATIONS – IMPACT SURVEY HELMET.
LEVELS [illegible] THE HELMET "[illegible]" OF A[illegible] [illegible] ARE SHOWN.

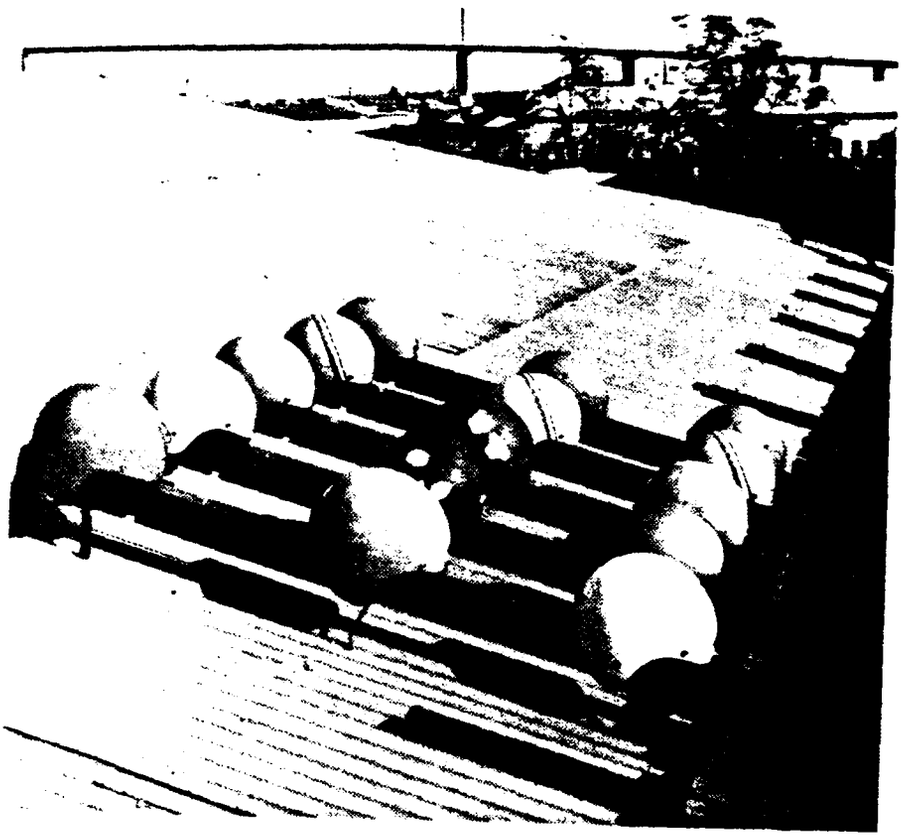

FIG. 3 HELMETS ON THE EXPOSURE RACK.

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